The Growth Performance, Heterosis Value, and Crossbreeding of Selected Japanese Broiler and Malon Quail

Endang Sujana[a,*], Asep Anang[a], Iwan Setiawan[a], Tuti Widjastuti[a]

[a]*Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, 45363, West Java, Indonesia*
Corresponding author: [*]endang.sujana@unpad.ac.id

Abstract – This research aims to address the scarcity of broiler quail chicks with relatively large bodyweight. The present study that involved crossbreeding is expected to produce quality broiler DOQ with relatively large body weight, high efficiency, and adaptability. The crossbreeding between two different strains is often used in a production system to utilize hybrid (heterosis). This study aims to determine the growth performance and heterosis value of selected Japanese broiler quail and crossbreeding. The experiment distributed 480-day-old quails (DOQ) to four treatments and six replicates (20 DOQ each) in a Completely Randomized Design. The treatments included selected Japanese quail ♂ x selected Japanese quail ♀ (JJ), Malon♂ x Malon♀ (MM), Malon♂ x selected Japanese♀ (MJ), and selected Japanese ♂ (JM) x Malon♀. The statistical analysis employed SAS's PROC GLM (General Linear Model) for Duncan's test. The observed changes were feed intake, body weight gain, feed conversion, and heterosis effect. This study found significant differences in feed intake, body weight gain, and feed conversion across treatments. The best performance was observed in the Malonx selected Japan (MJ) crossbreeding with a high weight gain (246.737 grams) and the lowest feed conversion (2,87) and feed (707.93 g).

Keywords: Performance; heterosis value; crossbreeding; broiler.

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I. INTRODUCTION

Poultry contribution to national meat consumption continues to increase year-on-year. Meat consumption in the 1970s was only 15%, but in 2018 it reached 81.16% (3.88 million tons), including 8.45% (0.33 million tons) local poultry meat [1]. It shows the importance of local poultry to provide animal proteins for Indonesian people; thus, it is crucial to consider the production and development aspects.

The type of poultry that mostly contributes to fulfilling meat demand is chicken, whereas quail meat has great potential. The quail farming business is an alternative to abundant meat and eggs besides chicken and duck. Besides the optimum egg production, the advantages of quail farms are the relatively fast reproduction, low input values, low maintenance, small-area occupation, and cheap selling price.

The development of quail farms in Indonesia started in early 1980 as local livestock. Japanese quail (Coturnix-Coturnix japonica) is commonly cultivated in Indonesia for its eggs. The byproduct of quails farming are hatchlings that cannot be used for breeding and culled female quails that are no longer productive. Furthermore, small-sized, and low-weight carcasses are the constraints in developing meat producers, so it is necessary to obtain broiler quails with relatively large bodyweight.

A farming breeder community in Yogyakarta has started to develop Malon quails (*Manuklondo*). Despite the low population, Malon is a potential broiler quail because it has a bigger body. An adult female Malon quail is larger than the Japanese quail (*Coturnix coturnix japonica)* regarding the average weights in the fourth generation, i.e., 333.92 ± 26.95 grams versus 269.15 ± 26.28 grams, respectively. The body weight of male Malon and *Coturnix coturnix japonica* quails are 296.30 ± 22.22 gram and 240.80 ± 17.42 gram, respectively [2]. Malon quail's existence as the crossbreed of French x local quails can be threatened when one of the parents must be imported continuously. Besides, the quail has not been able to adapt well in tropical Indonesia. Therefore, the efforts to develop broiler quail through crossbreeding programs are worth considering.

This study's crossbreeding objective is to combine the desired characters from the parents to create a new population of superior varieties. The crossed strains are Japanese quail (highly productive layer quail) and Malon quail (a relatively large quail). Crossbreeding is expected to produce quail

chicks with a relatively large body, high feed efficiency, and adaptability.

A well-maintained growing period would determine an optimum broiler quail's performance and production. The growth performance is measured from its quantitative properties, such as body weight, feed intake, and feed conversion. One of the benchmarks in describing productivity is by measuring the growth in poultry populations. Weight is a substantial factor in the selection study because it can increase efficiency [3]. Selecting broiler quail in the growing phase should be conducted at an early age, such as the third or fourth week, once they are positively correlated with slaughter weight and have few effects on the production and quality of eggs [4]. Furthermore, the selection process to increase body weight and reduce abdominal fat would improve the carcass-related traits [5].

The adequate availability of chicks, quality, and quantity, is an important production factor in quail farming. The efforts to obtain quality quail chicks are inseparable from farmers who perform the proper breeding maintenance. The breeding program is expected to obtain quality genetic improvement in quails and avoid the negative impact of breeding, such as low growth rate and inadequate production. Also, undirected breeding could cause low reproduction and production performance. The consequences of inbreeding are indicative of the low power of egg incubator, a shorter production life and life span, and a high rate of disabled quail [6].

Crossbreeding is an effort to produce quality broiler quail breeds. It is easy to measure and observed, and the result is quick [7]. Crossbreeding two different strains or breeds is common in animal production to harness a hybrid's advantages (heterosis) of a crossbreeding or so-called Hybrid vigor [8]. The weight and weight gain of crosses' quails at two, four, and six weeks were higher than those of both parents [9]. However, further research needs to seek improvement in the productivity of the crossbreeds.

This study reports a new finding in cross quails where Malon quail's domination is indicative of the plume color (81.82%), body weight, and body shape. Changes in behavioral patterns of the hybrids demonstrate more sluggish behavior that is typical of Malon quail. Malon quail and its hybrid have a bigger bodyweight and size than the Japanese quail, hence a higher potential as broiler quails. Accordingly, it is crucial to conduct a study on crossbreeding selected Japanese quail x Malon quail to produce quail meat. It aims to get the best commercial quails or final stock and contribute substantial information regarding broiler quails' development.

II. Material and Methods

A. Research Object

The objects of this research were quails as the parents of each strain, consisted of 36 selected male Japanese quail x 108 selected female Japanese quail (JJ), 36 male Malon x 108 female Malon (MM), and the cross of 36 male Malon x 108 selected female Japanese quails (MJ) and 36 selected male Japanese quails x 108 female Malon (JM).

Fig. 1 The Japanese selected quail

Fig. 2 The Malon quail

B. Research Ration

The ration used in the research was the commercial ration tailored to the growing phase that contained 22%protein and 2800 kcal/kg metabolic energy [10]; [11]. The nutrient content and metabolic energy ration of the research are presented in Table 1.

TABLE I
NUTRIENT COMPOSITION OF BASAL DIET

Chemical composition (Calculated)	
Crude Protein (%)	22.87
Crude Fat (%)	5.14
Crude Fiber (%)	5.16
Calcium (%)	0.78
Phosphorus (%)	0.5
Metabolizable Energy (kcal/kg)	3033

Source: Laboratory Analysis at the Center of Feed Quality Testing and Certification, Ministry of Agriculture, Bekasi [1].

C. Performance Observation

- *Feed consumption (grams per head).*

$$feed\ consumption\ (g) = ratio\ offered\ (g) - left\ over\ (g) \quad (1)$$

- *Bodyweight gain (grams per head).* Bodyweight gain is calculated with the following formula:

$$PBB\ (g/head) = final\ body\ weight\ (g) - initial\ body\ weight\ (g) \quad (2)$$

- *Feed conversion or FCR:* The conversion of rations calculated by the formula:

$$Feed\ conversoin = (total\ feed\ consumption) - (\text{body weight gain}) \quad (3)$$

D. Heterosis Calculation

Heterosis is a phenomenon where a cross exhibits superior characteristics that exceed both parents [7]. The heterosis

value of reciprocal crossbreeding between the selected Japanese quail and Malon is calculated as follows:

$$Heterosis\ (\%) = \frac{crossmean\ (MJ)\text{-}parentmean\ (JJ\ and\ MM)}{parent\ mean\ (JJ\ and\ MM)}\ x\ 100\% \quad (4)$$

$$\text{Heterosis (\%)} = \frac{\text{crossmean (JM)-parentmean (JJ and MM)}}{\text{parent mean (JJ and MM)}}\ x\ 100\% \quad (5)$$

E. Experimental Design and Statistical Analysis

The study used an experimental method in a Completely Randomized Design with four treatments and six replicates, each employed 20 quails, so the total quails are 480. The treatments were selected Japanese quails♂ x selected Japanese quail ♀ (JJ), Malon♂ x Malon♀ (MM), Malon♂ x selected Japanese ♀ (MJ), and selected Japanese ♂ (JM) x Malon♀. Each mating and crossbreeding were repeated 6 times, employing18 female quails and 6 males each. The eggs were hatched to obtain day Old Quail (DOQ), and their growth performance was observed.

The mathematical modelfor the Completely Randomized Design is $Yij = \mu + \alpha i + \varepsilon ij$.

The analysis of variance employed SAS's PROC GLM (General Linear Model) continued with the Duncan test.

III. Results and Discussion

A. Feed Intake

Feed intake is the amount of feed consumed at a particular time. Quails consume rations to meet energy and nutrient demands for life maintenance and production. The results on the growth performance of Malon quail, selected Japanese, and their cross up to 6 weeks old are presented in Table 2. Feed intakes are illustrated in Fig. 3.

TABLE II
THE GROWTH PERFORMANCE OF MALON QUAIL, SELECTED JAPANESE QUAILS, AND CROSSBREEDING

The observed variables	Quail strains			
	Malon (MM)	Selected Japanese (JJ)	Malon and Japanese Cross (MJ)	Japanese and Malon Cross (JM)
Feed intake (g)	725.26[a]	690.53[b]	707.93[ab]	701.00[b]
Body weight gain (g)	252.40[a]	212.47[c]	246.74[ab]	239.02[b]
Feed conversion	2.8789[b]	3.2505[a]	2.8699[b]	2.9394[b]

[a-b]Different superscripts within rows show a significant difference (P< 0.05)

Table 2 shows that the feed intake of Malon quails, selected Japanese quails, and their cross was 690,53-725.26 g. The statistical analysis showed significant differences in feed intake between Malon quail, selected Japanese quail, and cross (Table 2). Further, the Duncan test showed a significant difference (P<0.05) in feed intake among MM quails (725.26g), JJ (690.53 g), and JM (701.00 g), but no significant difference with Malon and Japanese cross (MJ). Furthermore, no significant difference was observed in feed intake between JJ and MJ, JJ and JM, and MJ and JM.

Figure 3 below shows a high feed intake in Malon quail, and the lowest is in selected Japanese quail and Malon x Japanese cross. The total feed intake up to 6 weeks in this study is higher than 448,7-485,8 g of layer quails [12]. Marcelo et al. stated that the total feed intake of male French quails up to 7 weeks old was 654,563 g, while the average feed intake of male broiler quails is 181.02 g per week [13]. This study's high feed intake was due to the relatively large body size and weight that required more feed to grow. The contributing factors to feed intake are body weight or size, growth rate, production, ambient temperature, and feed shape.

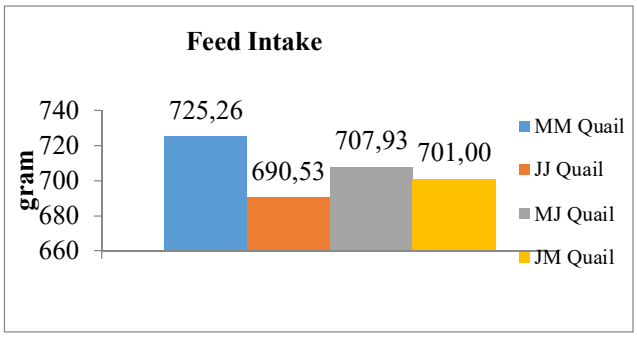

Fig. 3 The effect of treatment on feed intake

The main factor in different feed intake across treatments is the genetic factor. The relatively larger Malon quail requires more rations for growth and meat production. High feed consumption is highly dependent on the size of the animal's body, genetic characteristics (breed), environmental temperature, production rate, caging, individual feed intake, drinking water condition, quality and quantity of feed, and disease [14]. Poultry's characteristic in consuming rations is primarily to meet energy demand, so the daily feed intake correlates with their energy levels. The main factor of feed intake is the feed quality that includes nutrient content [15]. Furthermore, feed is one of the key factors to achieve optimum quail productivity; therefore, the quantity and quality of feed should remain the top consideration [16].

B. Body Weight Gain

The body weight gain of Malon quails selected Japanese quails, and their cross is presented in Table 2. A more detailed result on body weight gain in this research is illustrated in Fig. 4.

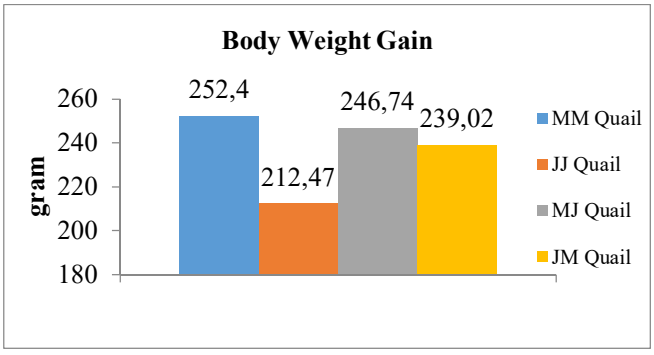

Fig. 4 The effect of treatment on bodyweight increase

The body weight gain reported in this study ranged between 212.47 and 252.40 g. The statistical analysis showed significant differences between Malon quails, selected Japanese quails, and their cross. Further, the Duncan test showed a bodyweight gain of Malon (MM) was 252.40 g, which is like 246.74 g of Malon x Japanese quail cross (MJ), but significantly different (P <0.05) from 239,024 g of Japanese x Malon cross (JM) and selected Japanese quail (JJ). Also, the selected Japanese quail (JJ) showed significantly

different results from Malon x Japanese cross (MJ), and Japanese x Malon cross (JM), while non significantly different results were observed between MJ and JM.

This study reported a relatively high body weight gain as observed in Malon quails and MJ cross. A contributing factor to weight gain is genetic traits inherited from the parents. Bodyweight gain can be improved by crossing different strains to reduce homozygous genes and increase heterozygosity. Crossbreeding is one of the alternatives to produce offspring that are expected to elicit complementary effects and render heterosis effects to increase productivity [8]. The crossbred layer quails produced better derivatives than the parents [17]. The practice of inbreeding in poultry farming would allow the superior genetics of parents be enhanced in the offspring [18] . Increasing body weight reflects quail ability to convert the feed substances in the ration to meat. The four main growth components are increased muscle weight consisting of proteins and water, increased skeleton size, increased total body fat in adipose tissue, and increased hair, skin, and internal organs. Quail growth is strongly influenced by genetics and the aim of each breeder's selection process, whether for an egg, meat, or both [19].

Increasing body weight is significant for livestock. The varied growth rate of quails is dependent on the quail's age. Quail would keep growing until it reaches the maximum growth at 6 weeks old then starts to descend. From 0 to 6 weeks, quails experience growth and development of the reproductive organs until they mature. Adult animals are still growing slowly, but the bones and muscle are no longer developing [20].

The growth of Malon quail selected Japanese quail and their crosses is presented in Fig 5. Furthermore, the body weight gain per week is illustrated in Fig 6.

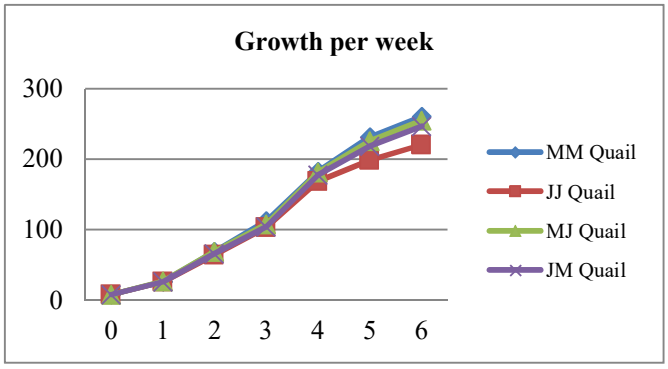

Fig. 5 Research Results Effect of Treatment on Growth

Growth is a biological phenomenon involving hyperplasia and hypertrophy. Growth is simply an increase in body size or weight [21]. The rate of growth in creatures has two phases, namely acceleration (increasing) and deceleration (decreasing). In the acceleration phase, the growth in livestock continues to increase rapidly but starts to slow down when entering the deceleration phase and remain constant. Furthermore, the acceleration period generally occurs before the cattle experience puberty (adult sex) and slow down afterwards [22]. The growth rate of Malon quail, selected Japanese quail and their crosses begins rather quickly, quickly, and slowly. The fastest weight gain in Malon and selected Japanese quails occurs at the age of 4 (four) weeks or before reaching adult sex. This is in line with [23] that the acceleration of growth generally occurs before the cattle experience puberty (adult sex), after that, the growth rate starts to slow down.

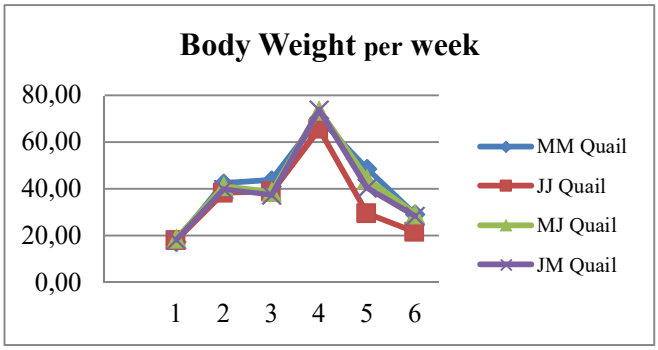

Fig. 6 The Effect of Treatment on Increased Body Weight per week

Increased body weight in Malon quail, selected Japanese quail selected and their crosses begin quickly, and slowly. Weight gain in the early weeks increased. The quickest occurred at the age of 4 (four) weeks and decreased in weeks 5 and 6. Increased bodyweight of the Malon quail, selected Japanese quails, and their crosses in the first week is relatively similar, but in the second week to the sixth week, Malon quail and the crosses were superior to selected Japanese quails. This is because of the influence of genetic traits inherited by their parent, i.e., Malon quail, with a faster body weight gain. It was in line with [21] that the growth potential (meat production) of livestock is closely related to both parents' inherited characteristics.

C. Feed Conversion

The feed conversion of Malon quail, selected Japanese quail and their cross is presented in Table 2. The feed conversion in this study ranges from 2.87 to 3.25. The results on feed conversion are illustrated in Fig. 7.

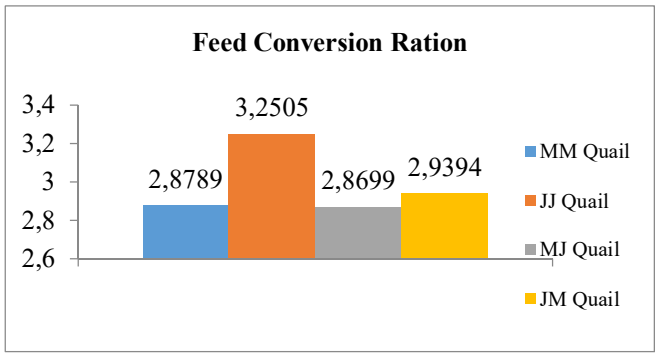

Fig. 7 The effect of crossbreeding to feed conversion ratio

The statistical analysis indicated significant differences in feed conversion. The Duncan test showed a significant difference ($P<0.05$) between Malon quail (MM) and selected Japanese (JJ), i.e., 2.8789 vs. .3.2505, but no significant difference was observed between Malon x Japanese cross (MJ) and Japanese x Malon cross (JM), i.e., 2.8699 vs. 2.9394. Furthermore, the feed conversion of selected Japanese quail rations (JJ) was significantly different from that of Malon x Japanese cross (MJ) and Japanese x Malon cross (JM), and

between the two quail MJ and JM crossbreeding showed similar results, or non-significant.

Based on Table 2, the feed conversion of 6-week quail is relatively low. The feed conversion of layer quails was 3.51-3.79 [12]. Furthermore, the average feed conversion of broiler quails was 3.86 [13].

The contributing factors to feed conversion include age, strain, energy and protein feed, temperature, and poultry health [24]. Also, it is suggested that feed conversion of quails is affected by genetic improvements to achieve a high body weight with low consumption, enabling better feed efficiency or lower feed conversion. Feed conversion is strongly dependent on the amount of feed intake and body weight gain. A high body weight gain would exhibit a low feed conversion ration compared to other quails that consumed a similar amount of feed but only gained a little body weight. Feed conversion could be the parameter of production efficiency. Therefore, a higher feed conversion ration indicates a low feed efficiency, and a low feed conversion ration means a higher feed efficiency. Feed conversion ration is very important because it correlates with production costs because it indicates the relationship between the amount of feed demand by animals/poultry to produce one unit of body weight or egg—accordingly, the lower the conversion rate, the better the feed quality [15].

D. Heterosis and Crossbreeding

Heterosis values can illustrate whether the Malon x Japanese quail reciprocal crossing's off springs show superior traits to the parents. Heterosis value (%) of MJ and JM cross is presented in Table 3.

TABLE III
HETEROSIS VALUE (%) OF MJ AND JM CROSS BREEDING

The nature of that observed	Parent average	Heterosis value		
		MJ	JM	Average
		---------- % ----------		
Feed Intake (g)	707,89	0,0051	-0,9739	0,4844
Body weight gain (g)	232,43	6,1537	2,8352	4,4945
Feed conversion	3,065	-6,3567	-4,0900	-5,2234

Table 3 shows that the heterosis value Malonx Japanese cross (MJ) ranges from -6.3567 to - 6.1537%, while the highest heterosis value is achieved from 6.1537% body weight gain, and the lowest is in -6.3567% feed conversion. Additionally, the heterosis value of Japanese x Malon cross (JM) ranges from -4,0900 to 2,8352%, the highest heterosis value is observed at a bodyweight gain of 2,8352% the lowest is in ration conversion of -4,0900. The heterosis values of both cross groups are both positive and negative. Positive heterosis means that crossbreeding can increase individual results' desired traits, while the negative value indicates poor crossbreeding results because the cross exhibits fewer desirable traits than the parents.

The negative heterosis value is on observation of the conversion of good quail (-6.3567%) or JM (-4.0900%). The conversion properties in MJ and JM cross are negative, but it does not reflect an inferior condition. The negative value would benefit the cross quails because they would need less feed to achieve feed efficiency.

The reciprocal crossbreeding between Malon and Japanese quails produced two groups of the cross in the observed properties. One of the goals of crossbreeding is heterosis to produce offspring with a better production rate than their parents [8]. MJ cross quails exhibit several properties superior to JM, reflected in the heterosis value of feed intake, body weight gain, and feed conversion ration.

The availability of adequate day-old quail (DOQ) in both quality and quantity is one of the most important production facilities in quail farming. The effort to get good DOQ certainly cannot be separated from the role of breeders who perform a sound breeding process. The start-up breeding program is carried out to produce an improved quality of quail as expected and avoid inbreeding, resulting in low growth and production. The implementation of undirected nurseries would trigger problems with low reproductive and production performance. This is indicated by the low egg hatchability, shorter production life, low survival rate, and quail disabilities, which also impact breeding [6].

Efforts to get quality broiler quail seeds is by crossbreeding. The crossing is a breeding program whose results can be quickly observed, measured, and harvested [7]. Crosses between two strains or different livestock breeds are often used in a production system to take advantage of hybrid superiority (heterosis) from the results of crossing or often referred to as Hybrid vigor [8]. Inbreeding will increase homozygote gene pairs and decrease heterozygous gene portions. On average, breeding can reduce performance, but an endless selection for several generations can produce heterozygous in the inbred line [21]. Meanwhile, to produce heterozygous cattle with a bigger variation from the population is through crossbreeding [25].

IV. CONCLUSION

The present study found significant differences in feed intake, body weight gain, and feed conversion. The best growth performance is identified in Malon x Japanese cross (MJ) with a high body weight gain (246.737 g), the lowest feed conversion (2.87), and 707.93g feed intake. The Malon x Japanese cross (MJ) shows the highest heterosis value on body weight gain (6.1537%), the feed conversion (-6.3567), and feed intake (0.0051).

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